PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 : F04D 1/12, 17/18

A1

(11) International Publication Number: WO 89/12170

(43) International Publication Date: 14 December 1989 (14.12.89)

(21) International Application Number: PCT/GB89/00633

(22) International Filing Date: 7 June 1989 (07.06.89)

(30) Priority data:
8813745.0 10 June 1988 (10.06.88) GB

(71) Applicant *(for all designated States except US)*: GENEVAC LIMITED [GB/GB]; Alpha Works, White House Road, Ipswich, Suffolk IP1 5LU (GB).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)* : COLE, Michael [GB/GB]; Mockbeggars Hall, Claydon, Ipswich, Suffolk IP6 0AH (GB).

(74) Agents: NASH, Keith, Wilfrid et al.; Keith W Nash & Co, Pearl Assurance House, 90-92 Regent Street, Cambridge CB2 1DP (GB).

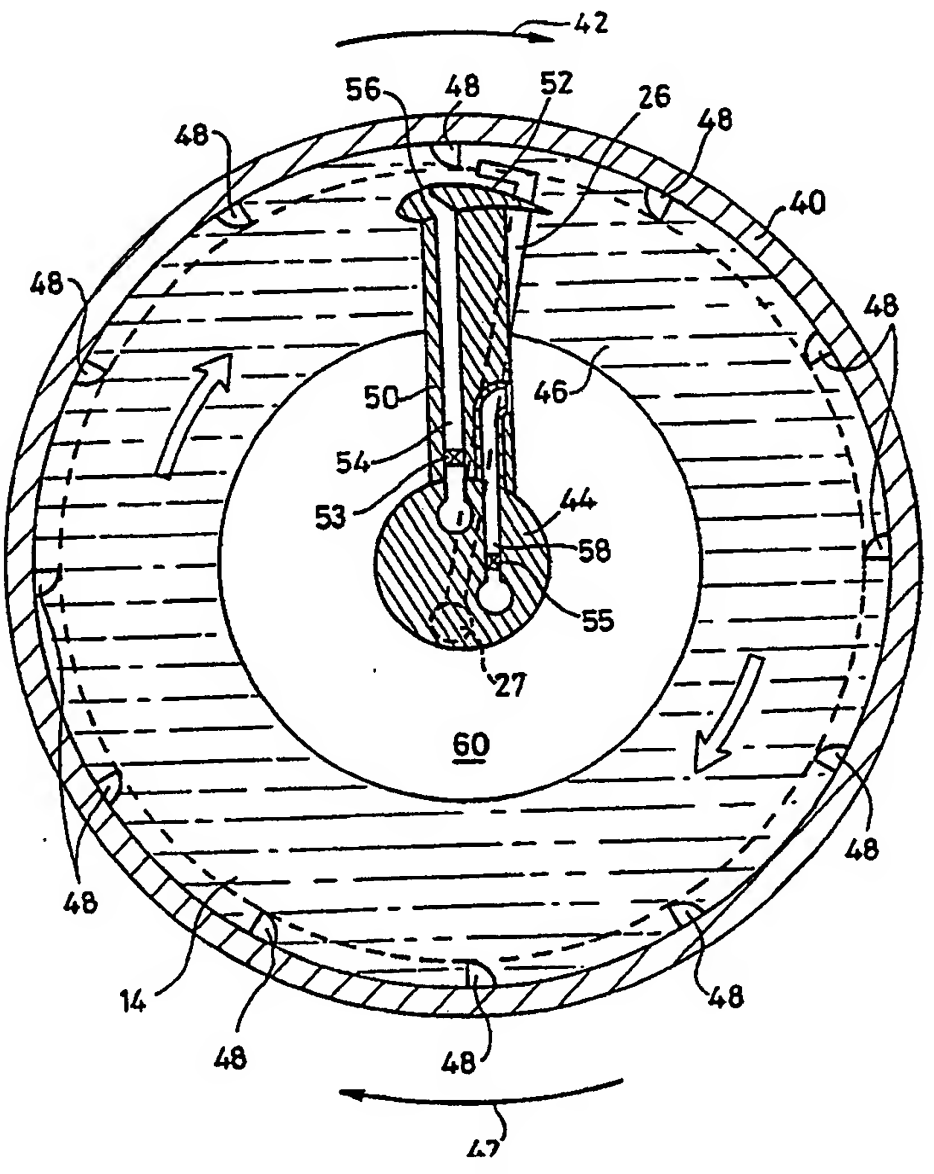
(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB, GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: METHOD AND APPARATUS FOR PROCESSING FLUIDS

(57) Abstract

A fluid pump has an outer cylindrical housing (40) rotating relative to a central hub (44) from which projects a radial probe (52) apertured in its external surface to be exposed to the flow therepast of a rotating annulus of operational fluid (14). The probe has an internal passage (54) for communicating the aperture (56) with the exterior, so that fluid is drawn into the pump due to suction created at the probe. A Pitot tube (26) is also exposed to the rotating fluid, and from an aperture thereof fluid is expelled from the pump. The fluid drawn into the probe (52) may be a gas to be scrubbed, and the rotating operational fluid may be an active liquid to dissolve impurities from the gas.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FI	Finland	ML	Mali
AU	Australia	FR	France	MR	Mauritania
BB	Barbados	GA	Gabon	MW	Malawi
BE	Belgium	GB	United Kingdom	NL	Netherlands
BF	Burkina Fasso	HU	Hungary	NO	Norway
BG	Bulgaria	IT	Italy	RO	Romania
BJ	Benin	JP	Japan	SD	Sudan
BR	Brazil	KP	Democratic People's Republic of Korea	SE	Sweden
CF	Central African Republic			SN	Senegal
CG	Congo	KR	Republic of Korea	SU	Soviet Union
CH	Switzerland	LI	Liechtenstein	TD	Chad
CM	Cameroon	LK	Sri Lanka	TG	Togo
DE	Germany, Federal Republic of	LU	Luxembourg	US	United States of America
DK	Denmark	MC	Monaco		
ES	Spain	MG	Madagascar		

Title: Method and apparatus for processing fluids

Field of the Invention

This invention relates to a method and apparatus for processing a fluid (liquid or gas), particularly using a pump of a type in which an aperture in a probe is exposed to a body of rotating fluid within the apparatus.

Background to the invention

In UK Patent No. 2154579 there is disclosed such a pump in which an apertured probe is subjected to a rotating body of liquid in the pump. It has now been surprisingly found that by adapting relatively small modifications, such apparatus (herein also called a pump), may be used for several other purposes, such as for mixing or separation of fluids and in particularly for the scrubbing or purifying of fluids having impurities therein.

Summary of the Invention

According to one aspect of the invention, there is provided a method of pumping comprising the steps of:

- relatively rotating the inner and outer parts of a pump which is filled with fluid and which includes an apertured probe within the body of rotating fluid so that suction is created at the aperture in the probe due to the passing fluid;

- communicating the probe with a first external region containing fluid which may be the same as, or different from, the fluid in the pump,so that fluid is drawn in due to the suction effect; and

- communicating the central region of the pump body with a second external region, whereby fluid can be displaced from the interior of the pump to the exterior thereof as fluid is sucked into the pump body.

The pumping action therefore uses the increase in the pressure of the fluid in the pump to expel fluid therefrom.

As indicated, the pumped fluid may be the same as the fluid rotating within the pump.

Generally, however, it is preferred for the fluid rotating within the pump to have a higher density than the pumped fluid.

In one example, for pumping air, the body of fluid rotating within the pump may be of a heavy inert gas such as Xenon or Sulphur hexafluoride.

In another example, the pumped fluid may be water using a body of rotating liquid within the pump, which may itself be water or more preferably a liquid of heavier density than water.

According to another aspect of the invention it is possible to suck in a mixture of fluids which separate under rotation within the pump, allowing differing fluids to be expelled at differing exits, e.g., one at the centre

and one near the periphery of the space defined between the two relatively rotating parts of the pump.

If the pumped and rotating fluids are different the body of rotating fluid need not fill the internal space defined between the relatively rotating inner and outer parts.

It is not always necessary for suction to be created at the probe; for example in the separation of fluids it may be preferred to feed the mixed fluids to the aperture under pressure.

If the same fluid is pumped as is in the pump body, it is preferred to establish communication between the body of rotating fluid and the exterior of the pump body at a point where the internal pressure of the pump is best utilised.

Thus, according to a further aspect of the invention, there is provided pumping apparatus comprising:

- relatively rotatable inner and outer pump parts;

- a body of fluid contained between the inner and outer parts and caused to move in rotation;

- an apertured probe exposed to the body of fluid to create suction at the probe aperture, whereby fluid is drawn in the pump through the probe; and

- a Pitot tube having an aperture exposed to the body of rotating fluid and through which fluid is expelled from the pump.

For best utilisation of the Pitot tube, its inlet end is preferably exposed to the body of rotating fluid near the outer periphery thereof, where the rotating fluid is travelling at its highest speeds.

In a pumping apparatus of the described kind, the suction effect into the probe can be increased by the provision of one or more protrusions on one of the relatively rotating parts which cause the rotating fluid to be locally squeezed as it passes the probe aperture. This locally increases the fluid velocity and thereby enhances suction. The effect is increased when one or other of the probe and the protrusion or protrusions, but not both, is or are rotating with the body of fluid.

When a Pitot tube is employed, it may be advantageous to utilise the squeezing effect on the body of fluid, due to the provision of the protrusion or protusions above described, to increase the speed of impact of the rotating fluid into the Pitot tube aperture. In a preferred arrangement of the pumping apparatus, therefore, protrusions rotating relative to the probe are provided for the dual purpose of enhancing suction of working fluid into the apparatus and of increasing expulsion of fluid through the Pitot tube. As with known pumps using a Pitot tube, the apparatus of the invention is primarily advantageous when the working fluid is a liquid.

Moreover, it may be advantageous to employ more than one apertured probe for sucking the working liquid into the apparatus; and analagously, two or more Pitot tubes may be employed to increase expulsion of the working fluid, the Pitot tubes being circularly distributed around the pump housing in the same way as are the apertured probes.

It will be apparent that, if a mixture of fluids of differing densities (normally a liquid and a gas) is sucked in via one or more apertured probes, the fluids will tend to separate under the action of the centrifugal forces existing within the apparatus, with the more dense fluid rotating radially beyond a central region filled with the less dense fluid. Thus the less dense fluid may be expelled through a centre outlet, and the more dense fluid expelled via a Pitot tube having its inlet disposed in the radially outer regions. This method is especially effective where a liquid/gas mixture is sucked in through the one or more apertured probes, but is also generally applicable to fluid mixtures containing fluids of differing densities.

Since the pump is capable of pumping mixtures ranging from 100% gas to 100% liquid, it may be applied to the pumping and separating of oil/gas mixtures such as occur in oilfields. In such case the pump would discharge virtually pure oil out from the Pitot tube, positioned near the outside of the rotating fluid mixture, and virtually pure gas through the centre of the pump.

A preferred probe is in the form of a wing extending parallel to the axis of the pumping apparatus and apertured parallel to said axis. When the outer part or casing of the apparatus rotates about a fixed central hub, this wing may be supported either by a strut attached to the fixed hub or to a fixed supporting disc mounted within the rotating pump housing. It is important for the wing not to reduce the ram effect of the rotating fluid on the Pitot tube and, if the Pitot tube is located adjacent the wing close to the periphery of the rotating body of

liquid, the wing may be cut away in line with the Pitot tube inlet.

In an alternative arrangement, however, the Pitot tube inlet is positioned radially within the wing (i.e. at a smaller radius from the pump axis than the wing). In this case, an additional advantage arises in that the apparatus is self-priming. Thus, assuming that on shut down a residual quantity of liquid is left in the housing, this will be constrained to rotate past the probe when the power is switched on and the housing starts to rotate, causing additional liquid to be sucked in until the rotating ring of liquid has built up to a thickness great enough for the Pitot tube to become operative.

Gas scrubbing has hitherto typically involved the passage of a contaminated gas through a body of neutralising liquid (ie a bath or curtain or spray of the neutralising liquid). This has required a fan or compressor to effect the passage through the liquid and intimate mixing has been difficult to achieve.

The present invention allows very intimate mixing of a gas and a neutralising liquid if the latter is employed as the working fluid in a pump of the type described in the aforementioned UK Patent No.2159579.

According therefore to another aspect of the present invention there is provided a method of gas scrubbing which comprises the steps of:

- relatively rotating the inner and outer parts of a pump which is filled with an active fluid and which includes an apertured probe within the body of rotating fluid so that

suction is created at the aperture in the probe due to the passing fluid;

- communicating the probe with a first external region containing a gas to be scrubbed, so that gas is drawn in due to the suction effect; and

- communicating the central region of the pump body with a second external region, whereby gas can be displaced from the interior of the pump to the exterior thereof as gas is sucked into the pump body.

The pumping action therefore uses the increase in the pressure of the fluid in the pump to expel gas therefrom.

The active fluid is chosen to dissolve or otherwise remove unwanted impurities in the incoming gas.

The active fluid may be a gas or a liquid or a vapour.

Where the active fluid is a liquid, the passage of the above mentioned protrusions over the probe(s) is believed to generate shock waves which cause relatively large bubbles of gas to be broken up to a very small size so as to give a large area of contact between the fluid and the gas, thereby improving the gas scrubbing.

Clean fresh active fluid may be added via the suction probe (normally used to input the gas) or via a central port in a static part of the pump, and spent active fluid may be recovered using a radially inwardly positioned Pitot scoop.

Alternatively or in addition two such pumps may be

multiplexed and the spent active fluid from the one may be replaced with fresh active fluid whilst the other is operational and vice versa.

The pump in accordance with the invention may analogously be used to purify a liquid by liquid scrubbing, in which a gas is passed through the liquid to remove or replace unwanted contaminants in the liquid. For example, clean air may be used to remove volatile solvents in solution in oil; or as a further example, nitrogen may be passed through water (eg sea water) containing dissolved oxygen, in order to strip out and replace the oxygen and thus help to prevent oxidisation eg in pipes.

Description of Embodiments

The method and apparatus of the invention will be described by way of example with reference to the accompanying drawings, in which :-

Figure 1 shows one embodiment of apparatus in accordance with the invention;

Figure 2 shows a second embodiment; and

Figure 3 shows a modification thereto.

The pump shown in Figure 1 has a cylindrical housing 10, and a tubular probe 12 extending through the housing wall. Filling the housing is a body of fluid 14.

Mounted co-axially within the housing is an impeller 16 which has a central core 18 and a number of radial blades 20. An external motor (not shown) drives the impeller 16

in rotation and the rotating blades 20 act on the fluid 14 to set this in motion. Thus, the rotating impeller causes the fluid to move in a circular path.

Also mounted in the housing is a Pitot tube 26, having its inlet near the periphery of the rotating fluid.

If the fluid 14 is a mixture of gas and liquid, the Pitot tube 26 will be used to remove the separated liquid, while the gas is removed from an outlet (not shown) towards the centre of the pump. On the other hand if the pump is being used as a liquid pump, the liquid can either be removed at low pressure and at a high flow rate from the said central outlet, or at a high pressure and at a low flow rate from the Pitot tube 26.

Where a flow control valve such as a one-way valve is to be incorporated in the inlet or outlet or both it may be located at equivalent positions such as are shown at 53 and 55 in Figure 2.

In the case of a multi-stage pump, the outlet of the Pitot tube 26 will be connected to the inlet of the next stage of the pump.

The probe 12 shown is in the form of a cylidrical tube and this tube will be connected to the space to be evacuated. Near the bottom of the tube is an opening 28 in the tube side wall. The end of the tube is closed. As shown, this opening 28 is open in the direction generally perpendicular to the flow of fluid indicated by the arrows 30. As the body of fluid 14 rotates, fluid is drawn through the tubular probe 12, through the opening 28 into the interior of the pump. At the same time, fluid is

rammed into the inlet of the Pitot tube 26, thence to be expelled to atmosphere.

More than one tubular probe 12 and more than one Pitot tube 26 may be located around the cylindrical housing to provide separate independent pumping devices or if connected in parallel to increase the pumping speed or throughput.

When pumping fluids (gases or liquids) which are less dense than the fluid medium within the pump, it is not essential for the pump to be filled, and it may operate with a rotating ring of fluid medium. Clearly the pump may alternatively act in the pressurisation mode.

The pump shown in Figure 2 has a housing 40 which is set in rotation in the direction of arrows 42 by an external motor (not shown). The housing rotates about a central hub 44. As would also be possible in the embodiment of Figure 1, a ring of fluid medium is shown at 46 in the position the latter will occupy when in use.

Radial protrusions 48 are provided around the inner surface of the housing 40. These protrusions help to set the fluid medium 46 in motion when the housing rotates, but also serve to enhance the suction effect in the probe as above described. The protrusions 48 may extend parallel to the axis of the housing or may be skewed relative thereto. Additionally or alternatively the probe may likewise be skewed.

A stem 50 (preferably streamlined in shape) extends radially from the hub 44 and carries a probe 52 which is located within the flowing fluid medium 46. The probe is

wing shaped and is aligned with the liquid flow direction and extends nearly the full length of the cylinder. Suction passage 54 opens in the radially outer surface of the probe and may be a circular hole 56 (or holes) or more preferably a slot, parallel to the pump axis. An exhaust passage 58 opens into the cylindrical space 60 at the centre of the pump, and both passages 54 and 58 pass out of the pump through the central hub 44.

In addition, a Pitot tube 26 communicates with a separate outlet 27 through the central hub 44. The Pitot tube 26 is located adjacent the wing probe 52, the latter if necessary having a cut-out to allow the rotating fluid medium to impact freely on the Pitot tube inlet. Also if necessary, cut-outs may be provided in the protrusions 48.

When employed to separate for example, a liquid/gas mixture, the chamber into which the gas is to be pumped is connected to the exhaust passage 58 and the inlet 54 to the liquid/gas mixture source. A chamber into which liquid is to be expelled is connected to the outlet 27 from the Pitot tube 26. References 53 and 55 denote possible positions for flow control valves, such as one way valves, if either or both is required, in the Figure 2 embodiment.

The fluid medium 14 or 46 may, in use of the pump for evacuation or for compression purposes, be oil or possibly water or, if hydrocarbon absence is essential, a low melting point liquid metal or alloy.

As with the Figure 1 embodiment, more than one probe and stem assembly such as 50, 52 and likewise more than one

Pitot tube 26, may be mounted to extend radially from the hub 44, so as to be circularly spaced around the housing.

Figure 3 shows a modification of the probe 52 of Figure 2. In this modification, the probe 70 carried by the stem 50 has a basic wing shape based on an axis which is curved.

The basic wing shape 74 is, however, cut away to form a linear ramp 76 on the leading side of the wing. The aperture 78, corresponding to the aperture 56 of Figure 2, lies at the top of this linear ramp 76. The ramp may alternatively be convexly or concavely curved.

Filters and/or valve means may be employed in the inlet and outlet as required, as exemplified by the previously referred to control valves 53 and 55.

Figure 3 also shows the Pitot tube 26 relocated in a position below the probe 70. This modification has the advantage that the pump is self-priming.

Although the Pitot tube has been shown in the illustrated embodiments in relatively close association with the stem 50 and probe 52, the precise positioning of the Pitot tube (or tubes, where more than one is employed) and the stem and the probe (or probes) need not be as shown, but may involve the positioning of the Pitot tube(s) at circumferentially spaced positions relative to the stem(s).

The invention also envisages the provision of means for adjusting the position of the Pitot tube(s) relative to the stem(s) and probe(s) to enable positions of maximum efficiency to be found.

Various modifications of the above described and illustrated embodiments are possible within the scope of the invention herein defined.

CLAIMS

1. A method of processing fluids comprising the steps of: relatively rotating inner and outer parts of a pump which contains a body of a rotating first fluid and which includes an apertured probe immersed in said body; communicating the probe with a first external region containing a second fluid which may be the same as or different from the first fluid, causing the second fluid to be fed to apertures in the probe; and communicating the central region of the pump with a second external region, whereby fluid can be displaced from the interior of the pump to the exterior thereof as the second fluid passes into the pump.

2. A method as claimed in claim 1 in which the probe is arranged to create suction at the aperture due to the rotating fluid, whereby the second fluid is drawn by suction through the aperture.

3. A method as claimed in claim 1 or claim 2 in which said first and second fluids are a mixture of fluids which will separate under rotation within the pump, allowing differing fluids to be expelled at differing exits, e.g., one fluid at the centre and another fluid near the periphery of the space defined between the two relatively rotating parts of the pump.

4. A method as claimed in claim 1 or claim 2 in which the second fluid is a gas to be scrubbed, and the first fluid is an active fluid chosen to dissolve or otherwise remove unwanted impurities from the incoming gas to be scrubbed.

5. A method as claimed in claim 1 or claim 2 in which the first fluid is a liquid to be scrubbed, and the second fluid is a clean gas adapted to remove or replace solvent constituents from the liquid.

6. A method as claimed in claim 4 or claim 5, further comprising the step of adding fresh active fluid via the apertured probe or via a static part of the relatively rotating parts of the pump.

7. A method as claimed in any one of claims 4 to 6, in which the spent active fluid is recovered using a radially inwardly positioned Pitot tube.

8. A pump comprising relatively rotatable inner and outer parts adapted to contain a body of fluid therebetween which is caused to move in rotation; an apertured probe exposed to the body of fluid to create suction at the probe aperture, whereby a fluid is drawn into the pump through the probe; and a Pitot tube having an aperture exposed to the body of rotating fluid and through which fluid is expelled from the pump.

9. A pump as claimed in claim 8, further comprising at least one radial protrusion on the rotatable part of the pump which causes the rotating fluid to be locally squeezed as it passes the probe aperture.

10. A pump as claimed in claim 8 or claim 9 in which the Pitot tube is positioned radially within the probe, so that the pump is self-priming.

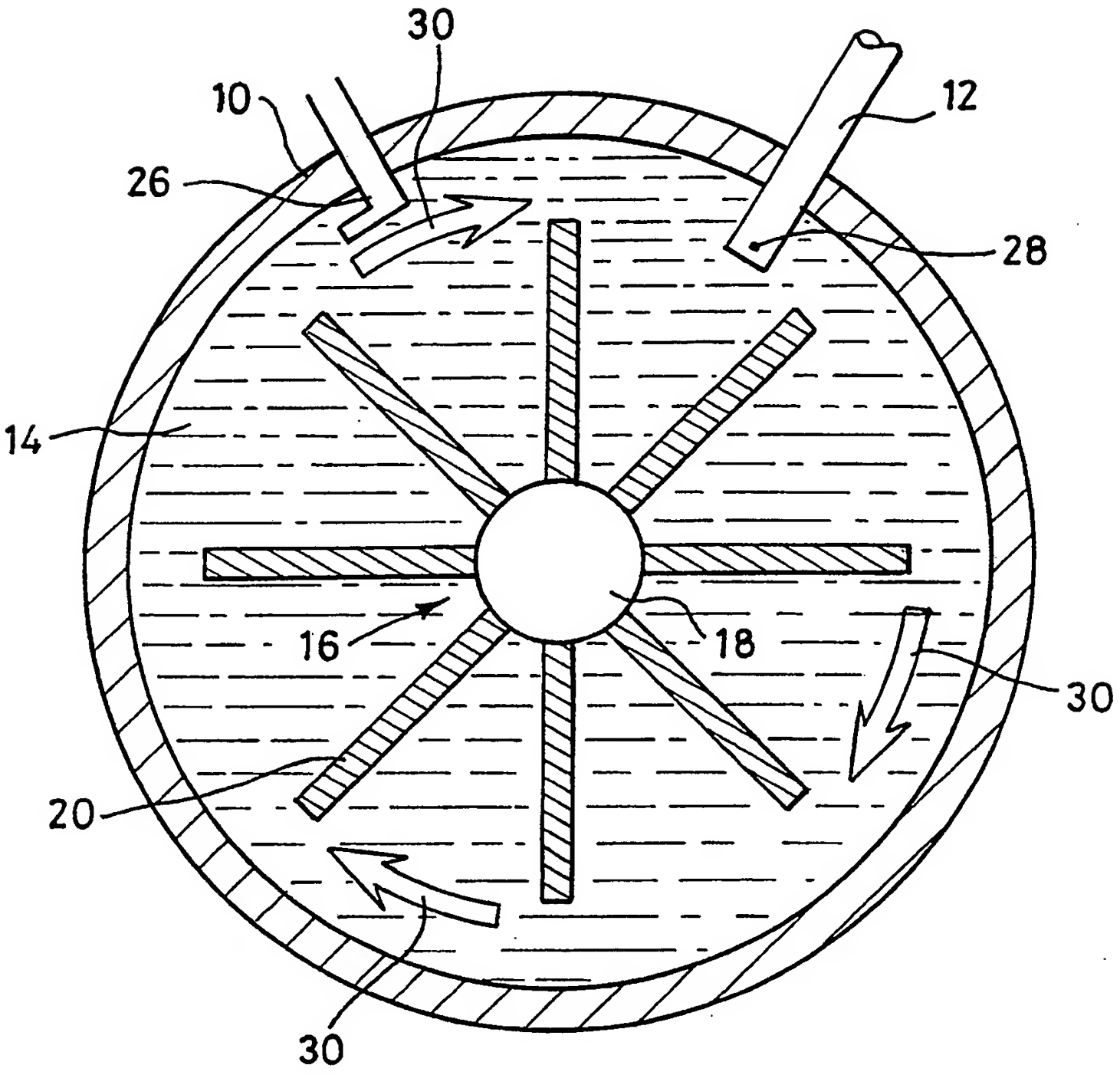


Fig. 1

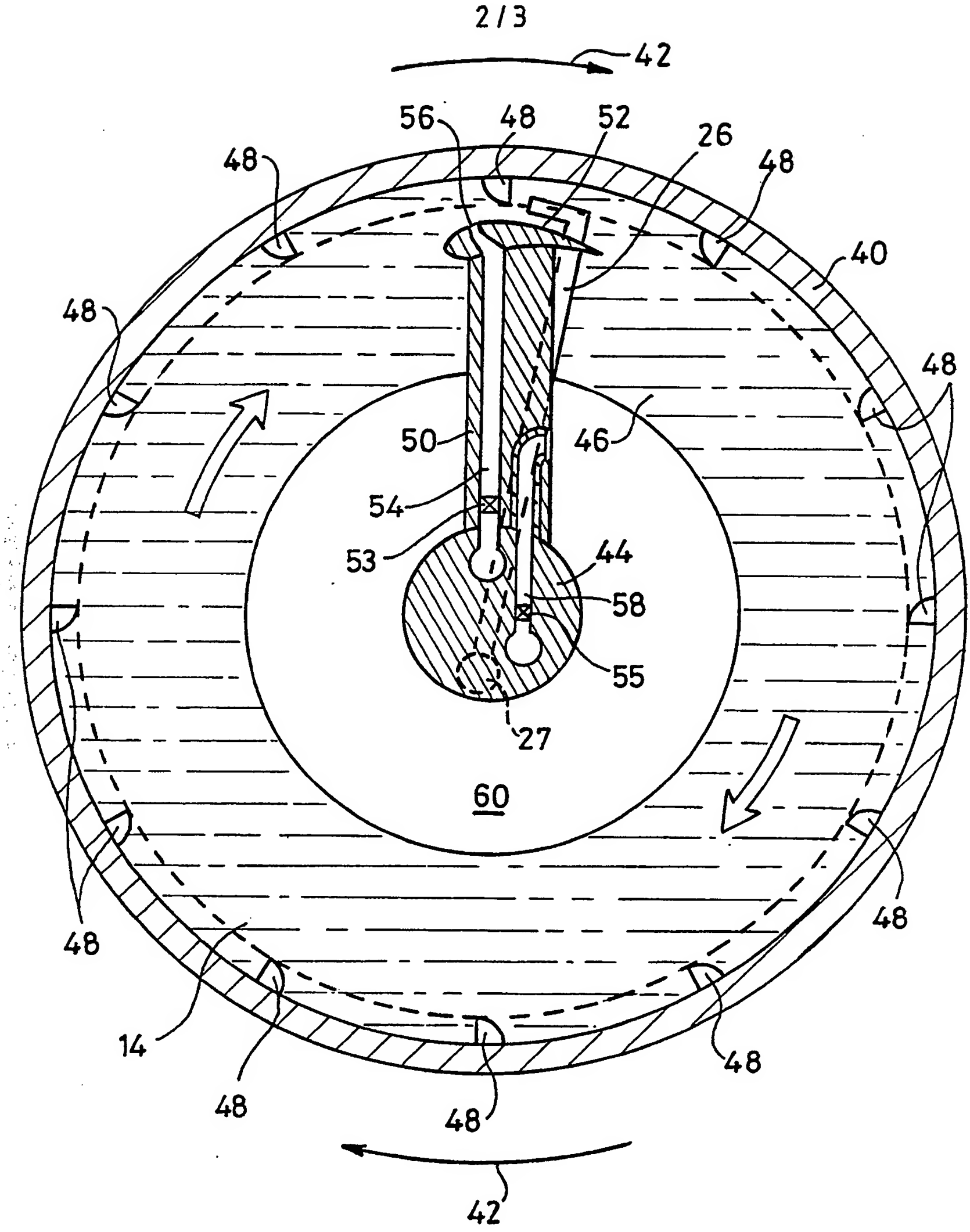

42
56
48
52
26
48
48
40
48
48
50
46
54
53
44
58
55
27
60
48
48
14
48
48
48
42

Fig. 2

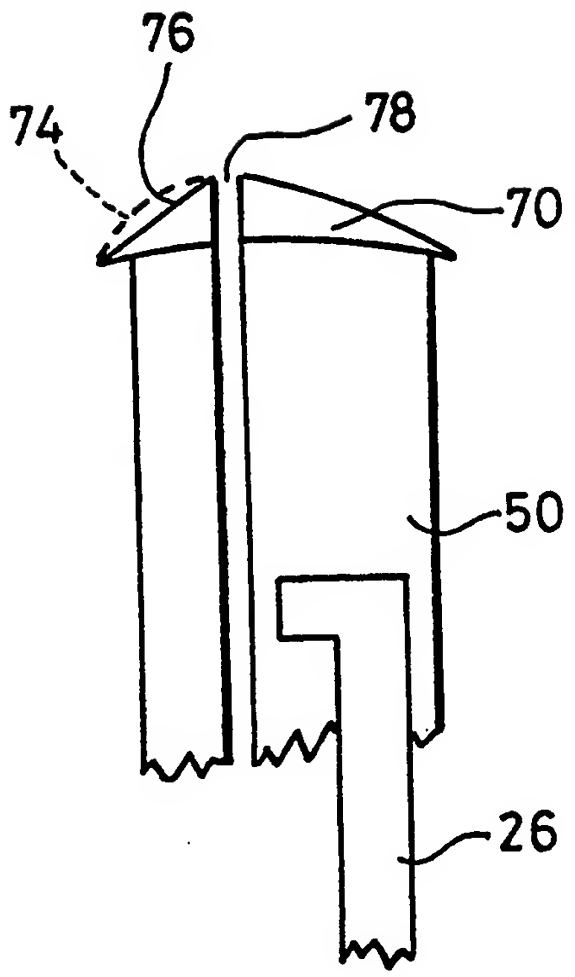


Fig. 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 89/00633

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 4 F04D1/12 ; F04D17/18

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 4	F04D ; B04B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	DE,A,3138315 (SIEMENS) 16 June 1982 see page 4, line 9 - line 10 see page 6, line 10 - page 7, line 32; figures 1, 2	1, 2, 8, 9
Y	---	3
Y	US,A,3936214 (ZUPANICK) 03 February 1976 see column 1, line 5 - line 12 see column 2, line 40 - column 3, line 24; figures 1, 2	3

X	FR,A,1193759 (LAVANDIER) 4 November 1959 see page 1, column 1, line 27 - line 41 see page 2, column 1, line 40 - column 2, line 43 see page 3, column 1, line 31 - line 43; figures 3-8	1, 2, 8, 9

	-/--	

° Special categories of cited documents : [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
31 AUGUST 1989	19 OCT 1989
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	TEERLING J.H.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	SOVIET INVENTIONS ILLUSTRATED, Section P/Q week E14, 19 may 1982. Derwent Publications Ltd., London GB. class Q, no D9565 E/14 & SU 840485 (Pilnik M B) 27 September 1979 ---	1, 2, 8, 10

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

SA 29182

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 31/08/89
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-A-3138315	16-06-82	None	
US-A-3936214	03-02-76	None	
FR-A-1193759		None	